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OCCURRENCE, LIFE-CYCLE, AND MAINTENANCE, UNDER ARTIFICIAL CONDITIONS, OF *MIASTOR*.

BY REGINALD G. HARRIS

From the Laboratoire d'évolution des êtres organisés, Paris, Prof. Caullery, Director.

The genus *Miastor* is extremely interesting for several reasons. It was in this genus that paedogenesis was discovered by Nicholas Wagner in 1861. Though at first Wagner misinterpreted the phenomenon which he observed, and though his observations were doubted, subsequent investigation has demonstrated the fact of paedogenesis as well as the occurrence of polymorphism in this genus. But investigations upon *Miastor* have been limited, due to some extent at least, to the lack of a suitable method of maintaining the larvæ of this genus in the laboratory. Now that a method, which will be discussed later, has been found, it seems to the writer desirable to make a short resume of the occurrence of Miastor, its life cycle, and polymorphism among the larvæ of the genus.

Occurrence of Miastor.

Miastor larvæ were first observed underneath the bark of decaying trees. I have found them in France under the bark of decaying oak, chestnut, and birch logs, and in edible mushrooms.

Other observers have found *Miastor* larvæ in many kinds of decomposing wood and in fermenting beet pulp. It may be safely concluded that their occurrence is fairly widespread in decaying logs and that they are sometimes present in other vegetable matter. Their habitat is not limited to Europe. In America Felt[1] found *Miastor* larvæ in 1910 under the partially decayed inner bark of chestnut rails.

In such environments *Miastor* larvæ usually occur in characteristic, compact, white colonial masses, a colony often containing a hundred or more individuals in close contact with each other. Among *Miastor* larvæ occurring in mushrooms I have not observed colonial arrangement. Here yellow or yellowish white larvæ are found singly although a single plant may contain many larvæ directly beneath the superficial cell-layers of the stalk or between the gills of the umbrella.

The Life-Cycle of Miastor.

Pædogenetic reproduction maintains in this genus during the autumn, winter, and spring, until the early summer, at which time pupæ occur, producing, after metamorphosis, male and female imagines. (The occurrence of pupæ, however, is not limited to the early summer. I have found them in nature in October, and in the same material pupæ continued to arise in the laboratory during the early winter. Though these were kept in conditions as natural as possible, at room-temperature, none of the pupæ has as yet given adults, though the usual period required for this metamorphosis in Miastor is about five days. Some of the pupæ have been destroyed by mould. It would seem that others, apparently in good condition, are in diapose.) The copulation of the adult flies results in the fertilization of the eggs which develop outside the mother into typical pædogenetic larvæ, and the cycle is complete.

Pædogenesis in *Miastor* is realized as follows: The ovaries of a typical pædogenetic larva produce eggs varying in number in different individuals, types and species. The development of larvæ from the eggs occurs within the body-cavity of the mother. The embryos continue to develop at the expense of the fat-bodies, muscles and surrounding tissues of the mother larva until a suitable growth is attained. The embryos seem to be suitably developed, and are usually active for several days previous to their escape. At the time of escape, the larva, while not full grown, is well formed, active, and capable of continuing its existence. The time required for a typical pædogenetic generation is about two weeks, though the period varies with indivuals and environmental conditions. White pædogenetic larvæ produce four to ten or more embryos.

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[1] Felt, E. P. Miastor americana, an account of Pedogenesis. Bull. New York State , 1911 vol. 147, pp. 82ff.

Polymorphism in Miastor Larvæ.

In all species of *Miastor* larvæ, which I have observed, there occur three distinct larval forms. Two are pædogenetic: viz. white and yellow pædogenetic larvæ, while the third is incapable of pædogenetic reproduction; it is the pupa-larva.

(1) *Typical white pædogenetic larvæ.*
The body of the larva contains fourteen segments. In the first or head-segment are the mouth opening and two antennæ. The mouth parts are arranged for sucking. The second and third segments contain the optic ganglia, and the third segment two eyes. In typical pædogenetic larvæ the eyes usually touch each other at their convex surfaces. The brain is in the fourth and fifth segments. Dorsal and partially posterior to it is the brain fat body. The salivary glands are in the fifth and sixth segments on either side of the œsophagus, their ducts opening in the mouth cavity. The œsophagus extends posteriorly from the mouth and opens into the intestine in the fifth segment. In this region the intestine enlarges and folds, forming two blind appendices, which are in turn divided into two parts each. The digestive tube continues to enlarge slightly until it reaches the region of the tenth segment where it narrows into the rectum which is not functional in later stages. The intestine contains a peritropic membrane for inclosing undigested food. Four tubes of Malpighi extend anteriorly from the region of the twelfth to the tenth segment. The anus is in the fourteenth segment. Here are also two symmetrical anal flaps which are easily visible when protruded. The larva contains well developed fat-bodies,

filling much of the body-cavity from the sixth to the fourteenth segments. The two ovaries occur in the region of the tenth segments, and are closely connected anteriorly with fat-bodies.

There are small chitinous points, arranged in four or more rows, extending around the larva between each segment from 2 to 14. Six chitinous hooks terminate the larva in the last segment.

There are two tracheal trunks on each side of the body, one laterally ventral, one dorsal. These have numerous cross branches, viz., one large branch connecting the two dorsal trunks in each segment from 6 to 13. From each of these branches two other minute branches extend posteriorly in each segment. Numerous branches and sub branches proceed from the ventral trunks. The dorsal and ventral trunks are connected in each segment from 6 to 13, another branch opening to the exterior on each side thus forming eight pairs of stigmata. There being no protruding spiracles it would seem difficult for the larvæ to remain long submerged. However, larvæ remain alive for long periods of time, a fortnight or more, when completely submerged in water under a cover-glass.

A series of large ganglia occur ventral to the digestive tube·

Locomotion results from stretching each segment and then contracting it, the process extending anteriorly. The rows of chitinous points prevent the larvæ from slipping.

The size of larvæ varies with species, individuals, cultures and age. New born pædogenetic larvæ of *Miastor metraloas*, average 1.35 x 0.16 mm, while pædogenetic mother-larvæ attain a length of from 3 to 4 mm.

2) *Yellow pædogenetic larvæ.*

Yellow forms (wanderers) are similar in general structure to white pædogenetic forms. They are extremely active. The body is usually slimmer, and the fat bodies less heavily developed than in white pædogenetic larvæ. The yellow pigment seems to occur for the most part in the fat-bodies. The eyes are noticeably larger than in other Miastor larval forms, and approach closely along their surfaces.

Yellow larvæ usually produce but a single embryo in the species (*Miastor metraloas*?) which I found in decaying wood. Yellow larvæ (undescribed) occuring in mushrooms, however, produce a large number of embryos. I have frequently observed twenty embryos in a mother-larva.

Neither the role of, nor the incentive factor producing, yellow forms is clear.

In active yellow larvæ I have observed a jumping locomotion. This seems to occur as a result of the larva bending its body until the anal chitinous hooks catch against the chitinous points of the second or third segment. Extension of the segments then tightens the tension which finally breaks with a snap resulting in a jump. The yellow forms are extremely active, and may often be seen lifting their heads and much of their bodies straight into the air.

3) *Pupa-larvæ.*

Larvæ which will metamorphose into pupæ are immediately distinguishable from other forms by means of three characteristic differences, though in general their structure is similar to that of white and yellow pædogenetic forms.

a) In newly born living pupa-larvæ the imaginal discs are visible. These occur laterally in the third, fourth and fifth segments. They are not present in pædogenetic forms.

b) The spathula sternalis, a structure typical of Cecidomyid larvæ, occurs ventrally in the third segment of the pupa-larvæ of *Miastor*. It is not visible in newly born living pupa-larvæ, but after four or five days becomes clearly visible, due to a yellowish coloration which later changes to orange and dark brown. The shape of this structure differs with various species. Its function is not understood.

c) The eyes of pupa-larvæ do not touch as in pædogenetic forms but are usually clearly separated.

The fat-bodies of pupa-larvæ are extremely well developed. The larvæ are active up to the time of pupation, unlike pædogenetic larvæ which of necessity become inactive with the progressive destruction of their muscles, due to the development of the embryos.

In *Miastor* as in all cyclorrhaphous diptera, the pupa is formed within the last larval skin. After the pupa-larva comes to rest the color of its skin changes from white to yellow, later to orange red and dark brown.

Under optimum conditions a period of about five days is required for the metamorphosis of pupæ into imagines.

The causes which lead to the occurrence of the various types of larvæ within a single species of *Miastor* are not known. I have observed all the various types occurring side by side in nature and in the laboratory. Springer's[2] belief that the yellow forms and pupa-larvæ are produced by the action of light upon typical pædogenetic mothers does not seem tenable, since I have observed all types occurring in the laboratory in cultures reared in the dark as well as in those reared in the light.

Method of Culture in the Laboratory.

In order to carry on investigations concerning the factors regulating the life-cycle of *Miastor* and those causing polymorphism among the larvæ of a single species, it seemed immediately desirable to find a suitable artificial medium in which cultures might be reared in the laboratory under controlled conditions. With this in view I attempted to rear *Miastor* larvæ on various media, finally meeting with success on a mushroom bouillon-agar innoculated with yeast.

The mushroom bouillon is made by taking equal parts by weight of mushrooms and water. The mushrooms are boiled in the water for 20-30 minutes. At the end of this time the mushrooms are withdrawn from the bouillon to which is added sufficient agar to make 4 per cent of the bouillon weight. The whole is heated until the agar is dissolved, when it is poured into small mouthed stock bottles stoppered with cotton, and sterilized; in this way the culture medium may be kept indefinitely. When it is needed for use, the medium is liquified in a hot water-bath and while still hot poured into culture dishes, and allowed to harden. For mass cultures of pædogenetic larvæ I have found petri dishes very suitable for culture containers. Since they allow but little loss by evaporation, the water of condensation falling back upon the culture medium, the medium remains moist, suitable for the reproduction of the yeast and the growth of the larvæ for some time. Larvæ may be more easily removed for examination from cultures reared in petri dishes than from those maintained in deep containers. Very small petri dishes may be used for individual cultures.

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[2] Springer, Fritz. Polymorphismus bei den Larven von *Miastor metraloas*. Zool. Jahrb Abth. f. Anst, vol. 40 p. 57 (1917).

After the agar has hardened, a little powdered yeast is sprinkled over its surface, to which the larvæ are transferred. Cultures are then placed in the incubator at 20-22 degrees Centrigrade.

I have employed this culture medium for *Miastor* larvæ of various species, and have observed in colonies reared in this way all the larval forms occurring under natural conditions.

It seems then that a method has been found for rearing cultures of *Miastor* larvæ in the laboratory under conditions which may be easily regulated. This method should be suitable for maintaining cultures of a pædogenetic insect in the laboratory for class work as well as for carrying on investigations concerning the factors influencing the life-cycle and the polymorphism of the larvæ of *Miastor*.

THE GENUS CYRTOPOGON (DIPTERA; ASILIDÆ)[1]

By A. L. Melander.

In the elaboration of Osten Sacken's table of Cyrtopogon given in Back's 1909 study of Robber-flies thirty species are included. This genus is particularly well represented in the Pacific States and several new forms have been discovered by western collectors since the publication of Back's review. Accordingly the following indentification table is appropriate to bring to date our knowledge of this group of especially interesting flies. References are given in the table to those species described since Back's paper was published.

Many of the species of Cyrtopogon exhibit sex dimorphism. This is particularly the case with those species having red antennæ. At times the males and females look quite unlike. The males present easy recognition characters in their elaborate and brilliant sex attire, but sometimes the more modest appearing females of several species resemble each other so closely as to be differentiated with difficulty.

The characters used in the table are for the most part reasonably constant. There is some individual variation in the color of the legs and of the hairs of face, hypopleuræ, scutellum, abdomen and legs, and in the extent of interruption of the abdominal fasciæ. Where such variations have been sufficient to cause doubt in interpreting the table, cross-references have been introduced for more accurate guidance. Types of the new species are in the writer's collection.

Key to the Species of Cyrtopogon.

1. Scutellum convex, generally long-pilose, usually shining or with touch of pollen at base, rarely pollinose among the species with long arista. . . . . 2.
Scutellum flattened and uniformly and quite densely pollinose; antennæ black. . . . . 32.

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[1] Contribution from the Zoology Laboratory of the State College of Washington.

2. Third antennal joint red; mystax largely white or yellow; (if halteres are blackish and face has white hairs, see *longimanus*; if large species with base of abdomen densely pilose, see *dasyllis*) . . . . 3.
Third antennal joint black. . . . . 11.
3. Tibiæ and tarsi more or less reddish. . . . . 4.
Legs black; claws white with black tip. . . . . 10.
4. Pile of scutellum and hypopleuræ white; apex of femora reddish; mystax mostly white; pile of tibiæ and pleuræ very long. (Can., N. H., Ct., N. Y., Mass., Va., N. C.
marginalis Lw.
Pile of scutellum black; of hypopleuræ more or less black; femora black; western species. . . . . 5.
5. Front tibiæ and tarsi of male silvery pilose on posterior side; wings hyaline. . . . . 6.
Legs not silvery, but sometimes with yellowish white hairs fringing tarsi; pile of male abdomen more or less tufted; wings with light clouding about veins, anterior crossvein near base of discal cell. . . . . 7.
6. Male: front tibiæ with fine white silky pile on outer side, becoming longer and denser apically; front tarsi with silvery hairs on anterior side of joints 2-5 in addition to the silvery hairs on posterior side; abdominal segments 1, 2 with pale yellow pile, longer on sides, remaining segments with very short hair, yellowish on 3, black on rest, segments 2-5 white-fasciate, interrupted on 4, 5.
(Col.) *pulcher* Back
Male: front tibiæ with moderately long silvery pile posteriorly, short yellow pile anteriorly; front tarsi with yellow hairs on anterior side of first two joints; abdomen with reddish yellow pile forming dense apical bands on segments 1-4, segments 2-4 silvery fasciate. (Alta.) (Can. Ent. liv. 278, 1922) . . . . . . *albitarsis* Curran.
7. Pile of abdomen yellow or fulvous at least on first segment, tip of male abdomen blue-black, segments 2-4 with complete fasciæ, sometimes hidden by dense pile in male; basal half of claws reddish. . . . . 8.

Male abdomen with lateral tufts of black not fulvous hair, female with less tufted black and white pile, abdomen with interrupted white pollinose fasciæ; claws black, front tarsi of male very long. (Or.) (Proc. Cal. Acad. Sc., 1919, 233) . . . . *perspicax* Cole

8. Male abdomen with black tuft on sides of second segment, a dorsal pollinose vitta on segments 2-5, female abdomen with lateral pile pale yellow and almost entirely confined to basal two segments; male front tibiæ with white pubescence toward tip, tarsi yellow with brush of yellowish-white hairs along entire outer face and with black bristles inside, tarsi of female reddish; central hairs of face mixed black and white. (Wash.) . . *glarealis*, n. sp.

Male abdomen with dense fulvous pile arranged in tufted bands across segments 2-4, no dorsal vitta, yellow pile of female abdomen continuing on third segment. . . . 9.

9. Segments 5-7 of male abdomen with dense tufts of short black velvet pile; front tibiæ and tarsi without brush on posterior side, bristles black, some white pile on extensor face of male tarsus; female with tarsal joints tipped with black and with center hairs of face white. (Cal., Wash.) . . . . *aurifex* O. S.

Segments 5-7 of male abdomen not tufted; posterior edge of front tibiæ and tarsi of male with uniform brush of white hairs containing white bristles; female with yellowish tarsi and with central hairs of face yellow. (Or., Id.) (Proc. Cal. Acad. Sc. 1919, 230.) . . . . . *auratus* Cole

10. Thorax white-gray pollinose, markings nearly obsolete; wings hyaline; face and front heavily coated with cinereous pollen. Male unknown. (Cal.) . . . . . *cretaceus* O. S.

Thorax of male black, of female brown and gray; wings of male black, of female subfuscous; male front tarsi very long, silvery on extensor side, hind tibiæ and tarsi silvery pilose. (Cal., Or., Wash.) . . . . *princeps* O. S.

11. Style nearly as long as third joint of antennæ; wings with distinct dark spots on furcations and crossveins; scutellum often dusted. . . . . 12.

Style evidently shorter than third joint of antennæ. . . 15.

12. Thorax compressed gibbous, the undivided median stripe bearing a strong mane of long black pile and setiform hairs; scutellum margined with long black setæ; costal and marginal cells hyaline; halteres black. (Wash.) . . . . *maculosis* Coq.

Thorax convex as usual, with erect black pile but no mane; scutellar bristles less developed; middle dorsal stripe geminate. . . . . 13.

13. Costa fringed with uniform close hairs; pile of face tipped with white; halteres black. (Cal., Or., Wash., B. C.) *nebulo* O. S.

Costa with only microscopic hair; white tips of facial hairs less evident; costal and marginal cells brown apically. 14.

14. Halteres black; a single spot in first basal cell at origin of third vein. (Id., Wash.) . . . . . . *punctipennis*, n. sp.

Halteres yellowish; first basal cell with two blackish spots near middle. (Wash., Or.) . . . . . *varipennis* Coq.

15. Abdomen with dense erect pile forming a bright yellow band across middle part, and black at tip. . . . . 16.

Abdomen not densely clothed but sometimes with lateral or parted tufts of pile in male. . . . . 18.

16. Style short and thick, almost square; wings hyaline; anterior crossvein near base of discal cell; anterior tibiæ and front tarsi with dense white pile on extensor face; yellow pile of abdomen confined to basal three segments. (Wash.) . . . . *semitarius*. n. sp.

Style longer than wide; anterior crossvein near middle of discal cell; hairs of legs black aside from the fulvous recumbent pubescence on inside of front tibiæ. . . . . 17.

17. Wings of male with large black sharply limited spot; all hairs of head black; yellow hairs of abdomen confined to segments 2-4 (Col., Id.) . . . . *dasyllis* Will.

Wings with dark spot more suffused; hairs of face and beard yellow; yellow hairs of abdomen extending on fifth segment. (Wash., Or., Id., Cal., N. Y.) . . . *dasylloides* Will.

18. At least hind tibiæ in part reddish, usually anterior pairs also more or less reddish. . . . . 19.

Legs entirely black, sometimes hind tibiæ with dark castaneous tinge. 27.

19. Wings of male with two large black marks; vertex little excavated and heavily deep golden pollinose; mesonotum deep golden pollinose, the four corners shining; mystax golden; abdomen with yellow lateral tufts; segments 2-5 with broadly interrupted posterior fasciæ. Wings of female infuscated over apical part and over end of anal cell; color of pile and pollen less deep. Anterior crossvein near middle of discal cell. (N. H., Minn., N. M., Col., Wyo., Id., Or., Wash.) . . . . *bimacula* Walk.

Wings not bimaculate; vertex more evidently excavated; 20.

20. Abodmen of male with a large tergal patch of dense fulvous tomentum; hypopleural hairs white.(Ont.) *vulneratus*,n. sp.

Abdomen without such mark of fulvous tomentum. . 21.

21. Male front tarsi with recumbent silvery pile, last two joints of middle tarsi of male with disk of black hairs; gray pruinose marks of abdomen very small and located at hind angles of the segments. (If male front tarsi silvery but middle tarsi without disk, see *tacomæ*.) . . . . . 22.

Front tarsi without silvery recumbent hairs and middle tarsi without black disk. . . . . 25.

22. Silvery hairs of male front tarsi parted; black disk of middle tarsi confined to last two joints. . . . . 23.

Silvery hairs of front tarsi not parted, beginning on second joint; short black hairs on third joint of middle tarsi beginning the disk; pulvilli dark brown. . . . . 24.

23. First two segments of abdomen with white pile on sides, in male contrasting with black pile on remainder; front metatarsi of male not silvery above, but densely beset on both sides below with black bristles; pulvilli whitish. (Cal., N. M., Wyo., Col.) . . . . *callipedilus* Lw.

Abdomen with black pile over all; front metatarsi of male silvery above and not spinose beneath; pulvilli brown. (Cal.) . . . . *cymballista* O. S.

24. Scutellum and most of thorax shining; pile of abdomen yellow and black. (B. C. ,Alta., Wash.) (Can. Ent. 1922, 277) . . . . *willistoni* Curran.

Base of scutellum and much of thorax brown pollinose; pile of abdomen yellow. (N. M., Utah, Id., Col., Neb.) . . . . *plausor* O. S.

25. Gray pruinose marks of abdomen confined to hind angles of segments; pile of face deep golden; pile of hypopleuræ yellow, of abdomen yellow except at end; tibiæ abruptly black on apical half. (N. S., Queb., Ont., N. H., Mass., N. Y., Ct., N. J., N. C., Fla., Ill.) (If legs are entirely dark chestnut, see *alleni*) . . . . *falto* Walk.

Gray pruinose marks following hind margins of abdominal segments; pile of face whitish, black on sides; hind tibiæ not black apically. . . . . 26.

26. Hairs of hypopleuræ black; abdominal fasciæ narrowly interrupted, sometimes entire in female; pile of abdomen mainly black. (Col., N. M., Cal., Id., Wash., B. C.) . . . . *montanus* Lw.

Hairs of hypopleuræ white; abdominal fasciæ entire; pile of abdomen white Male unknown. (Cal., N. M., Or.) . . . . *leucozona* Lw.

27. Middle segments of abdomen with complete fasciæ; male front tarsi elongate, tarsal hairs chiefly white, long on upper side of basal three joints of hind pair, tarsal hairs of female chiefly black; hypopleural hairs black; halteres blackish brown; extensor hairs of hind tibiæ white. (Cal., Wash., B. C.) (If hind tibiæ are dark chestnut color, see *montanus*) . . . . *longimanus* Lw.

Fasciæ of abdomen interrupted, sometimes reduced to lateral spots; crossveins, etc., usually clouded. . . . . 28.

28. Fasciæ broader than long, following the hind margins; front tarsi of male slender . . . . 29.

Fasciæ confined to hind angles of segments. . . . . . 30.

29. Front tibiæ and tarsi of male with not dense white pilef which does not conceal the ground-color; hind tarsi o,

male darker than others; claws broadly yellowish; humeri subshining. (Mont.) . . . . *rufotarsus* Back.

Front tibiæ and tarsi of male with appressed silvery pile concealing the ground-color at least of tarsus; middle tarsi darkest; claws black the base reddish; humeri and adjacent region of thorax heavily silvery-white pruinose. (Wash.) . . . . *tacomæ* n. sp.

30. Front tarsi of male with single row of silvery pile from very base; last two joints of middle tarsi with the flat disk of black pile longer than broad; pile of abdomen yellowish white at base, black apically. (Wash., Or.) (If front metatarsi of male are not silvery, see *Willistoni*) . . . . *præpes* Will.

Front and middle tarsi of male not ornamented. . . . 31.

31. Scutellum with long black pile; mystax and hypopleuræ pile black; pleuræ shining above; notal pattern including mark like a tuning-fork. (N. H., N. Y., N. C.) *lyratus* O .S.

Scutellum with short white pile; mystax partly white, hypopleural pile white; pleuræ densely white pruinose. (N. H., N. C.) . . . . *alleni* Back.

32. Abdomen with pollinose markings at least of segments 2-4 extending from side to side. . . . . 33.

Abdominal fasciæ interrupted, sometimes subinterrupted, that of first segment sometimes entire. . . . . 39.

33. Greater part of middle segments of abdomen covered with gray pollen and the front angles polished; hypopleural pile white. . . . . 34.

Greater part of abdominal segments shining, or if largely pollinose the pollen extending along the sides so that the front angles are not polished. . . . . 36.

34. Pollen denuded in circular spot in middle of each tergite; tibiæ with many white bristles, male with brushes of white hair on front side of middle tibiæ below knee and on front side of middle metatarsi. (Wash.) . . . *ablautoides*, n. sp.

Middle of tergites pollinose, or if shining not forming a central round spot; white hairs of legs evenly distributed. . . . . 35.

35. Hypopleural pile black; hairs of hypopygium yellowish white; mystax white; abdomen of both sexes gray except front angles of segments; tibial bristles white except those at tips and on front side of first pair. (Cal.) . . *rattus* O. S.

Hypopleural pile white; hypopygial hairs black above; mystax white and black; anterior half of male abdominal segments shining; tibial bristles black, a few pale ones on extensor side of hind tibiæ of female. (Wash.) . . . . *cæsius*, n. sp.

36. Face convex below but not gibbous, facial pile dense and white; tibiæ reddish at base; male abdomen broad, with sides and posterior margins pollinose, female abdomen narrow, anterior margins of segments 2-4 sometimes also pollinose. (Or., Wash.) (Proc. Cal. Acad. Sc. 1919, 230) . . . . *anomalus* Cole.

Face more gibbous, its pile largely or wholly black. . . 37.

37. Legs largely brownish red; geminate stripe of thorax distinct and complete; pollen of abdomen confined to posterior and side margins of segments; style one-third the third antennal joint; scutellum without bristles; face and front brownish gray. (Ks., Col., N. M.) . . *profusus* O. S.

Legs black; scutellum with black bristles. (If scutellum with only marginal pile, see *nugator* female if facial hairs all black, or *cæsius* male if facial hairs white.) . . 38.

38. Abdominal fasciæ extending along posterior edge of segments; stripes of thorax very distinct. (Cal.) *evidens* O. S.

Abdominal fasciæ extending along anterior margin of segments 2-6 but not reaching sides, posterior angles with spots of white pollen; stripes of thorax indistinct; style one-tenth the third antennal joint. (Cal.) *cerussatus* O. S.

39. Legs in part reddish; mystax black. . . . . 40.

Legs black, rarely the knees alone brownish. . . . . . 41.

40. Hypopleural pile whitish; mystax rather sparse; wings hyaline; mesonotum largely gray. (Ariz.) . *tibialis* . Coq.

Hypopleural pile black; mystax dense; wings brownish apically, crossveins clouded; mesonotum largely brown. (Or.) . . . . *dubius* Will.

41. Bases and hind angles of abdominal segments pruinose, sides of first segment pruinose; anterior crossvein beyond middle of discal cell; mystax and hypopleural hairs mainly black; thorax largely gray, marks diffuse, pleura bear of pile, scutellar margin with strong bristles. (Cal.) . . . . *nigricolor* Coq.

No fasciæ at base of segments; scutellum more or less pilose; thorax darker. . . . . 42.

42. Hypopleural pile wholly or in large part white. . . . . 43.

Hypopleural pile wholly black. . . . . 47.

43. Pleuræ with polished spot beneath wings; tibial bristles white; first abdominal segment with entire fascia. (N. S., Mass., N. Y. Md. Va.) . . . . *lutatius* Walk.

Pleuræ wholly pollinose and with some fine pile; tibial bristles mainly or entirely black; fascia of first segment of abdomen interrupted. . . . . 44.

44. Scutellar pile pale yellow, wings hyaline; facial pile mixed white and black. (Or.) (Proc. Cal. Acad. Sc. 1921, 255) *thompsoni* Cole

Scutellar pile black. . . . . 45.

45. Scutellar pile abundant; wings dark, especially in male; facial pile white in male, black in female. (Or.) (Proc. Cal. Acad. Sc. 1919, 233) . . . . *infuscatus* Cole.

Scutellar pile sparse and marginal; facial pile black. . . 46.

46. Tarsal claws yellowish with black tip; wings hyaline; median stripes as distinct as the blackish lateral spot. (Cal., Or., Wash., Id.) . . . . *nugator* O. S.

Tarsal claws reddish at base, otherwise black; wings brownish hyaline; median geminate stripe of mesonotum abbreviated posteriorly and less distinct than the rich dark brown lateral spot. (Cal. Or.) . . . . *rejectus* O. S.

47. Front and face broad, cinereous; notal marks often feeble. (Cal., Or., Wash.) . . . .*sudator* O. S.

Front and face relatively narrow, brownish; notal stripes coalescing, dark brown. (Cal., Ariz., N. M., Id.) *positivus* O.S.

Cyrtopogon ablautoides, new species

Male.—Length 11 mm. Head cinereous pollinose, frontal hairs whitish, becoming black at orbits, hair of center of face dense and white with slight yellowish tinge, of sides and beneath black, hairs of occiput abundant, silvery, nearly white, antennæ slender, the style one-fourth as long as third joint, its basal segment scarcely visible. Thorax dusted with yellowish-gray pollen, the geminate stripe interrupted one-third the distance in front of scutellum, lateral stripes nearly obsolete, slightly darkened in front of suture and a weaker indication behind, three strong lateral presutural bristles, four intraalar, postalar callosities with four black bristles; hairs of notum white in front, a few blackish hairs intermixed behind, scutellum flat, brownish-gray pollinose, disc with erect white pile, margin with white pile, about six black setæ, pleuræ gray pollinose with yellowish tinge on mesopleura which also bears long white pile, trichostical hairs yellowish-white. Abdomen with shining or subshining anterior margins to the segments the posterior margins white pruinose, a central subshining black spot on each of segments two, three and four, sides of segments two, three and four subshining except posteriorly, the first three segments bearing dense lateral tufts of whitish yellow hair, hair of remaining segments sparse short and white, hypopygium small and subshining black. Legs dusted, femora with whitish pile, front tibiæ bristly, the bristles of extensor face stout and black, of posterior face strong and yellow, of interior face fine and setiform, flexor surface golden pubescent: middle tibiæ with dense cluster of white pile at two-fifths its length on anterior face, bristles mainly whitish, similar tuft of white pile on front face of middle metatarsus; bristles of hind tibiæ whitish and black mixed, claws black, pulvilli alutaceous. Halteres with pale yellow knob, calypteres yellow; wings hyaline, veins narrow and black, anterior crossvein at two-fifths length of discal cell, anal cell closed or narrowly opened at margin.

Female.—Apical segments of abdomen shining black.

Types.—Mabton, Washington, May 3, 1911 (Melander). Paratypes from Lind, Wash. May and June (F. W. Carlson), Columbia River near Trinidad, Washington, May 1, 1919 and Wenatchee, Washington, April 12, (Melander). Four males and six females. The species presents a curious superficial resemblance to *Ablatus mimus* O. S. with which it is associated in the sandy desert region.

Cyrtopogon caesius, new species

Male.—Length 9 mm. Related to *C. rattus* O. S. Head heavily whitish pruinose, vertical hairs white and black mixed, facial hairs similar but longer, the black hairs predominating below, occipital pile abundant, white and very fine, third antennal joint long and slender, the arista not very distinct, quite as thick as end of third joint and in length about one-fourth the latter, its basal joint undeveloped. Thorax heavily pollinose, its pile rather short sparse and black, three black lateral bristles and a cluster of about three postalar, four intraalar bristles, median geminate stripe black, lateral stripe interrupted at the suture so as to form a broad presutural blackish round spot and an indefinite broad postsutural stripe, front margin and humeri grayish-white; scutellum flat, white pruinose, its margin with black setiform hairs and white pile; pleuræ uniformly white pollinose, pectus with fine white pile, trichostical hairs dense and white. First abdominal segment entirely white pruinose, second and third segments with narrow white band on front margin and broad white band on hind margin, the intervening space shining black, remaining segments shining black, the hind margin broadly white pruinose, the white bands do not encroach forward on the sides of the tergites; hypopygium scarcely widening at termination of the abdomen, lateral valves cupuliform; hairs of abdomen long tufted and white at side margins of basal three segments, largely short and black on remaining segments, under side of hypopygium with yellow hairs, tuft of grayish hairs at apex of venter. Legs entirely black, femora and posterior tibiæ white pilose, front tibiæ with black pile on front face, dense yellow pubescence on inner face and loose comb of black setiform hairs on both outer and flexor surfaces and another comb of black bristles on forward face, setiform hairs of middle tibiæ long and black, of hind tibiæ almost bristle-like, forming rows on extensor and anterior faces, claws black, pulvilli alutaceous. Halteres of each specimen with rosy knob, calypteres yellowish; wings hyaline, veins black, anterior crossvein at one-third the length of the discal cell, anal cell open as widely as the length of anterior crossvein or less.

Female.—White hairs predominating on vertex and upper part of face, marginal bristles of scutellum stronger, white pruinosity of abdomen more extended, the second third and fourth segments with shining narrow base, expanding as an anterior quadrate shining spot at side margin, remainder of segment white pruinose, posterior segments similarly colored except that the lateral expanse of shining area is more triangular, seventh and eight segments polished black. Tibial bristles stronger.

Types.—South slope of Mount Adams, Washington, July 24, 1921. (Melander). Two males, seven females, taken at an elevation of 4000 feet.

Crytopogon glarealis, new species

Male.—Length 14 mm. Head with golden tomentum, upper hairs rather sparse and black, mystax black, the lowermost hairs mixed with golden, beard white, third antennal joint reddish-yellow, style black and one-fifth the length of the third joint. Mesonotum with fulvous pollen, middle stripes very indistinct, humeri and postalar callosities shining, pollen denuded on posterior half of thorax except a quadrate spot next to scutellum, scutellum convex and shining except for a touch of pollen at middle of base, notal hairs sparse and black, scutellar hairs mostly black, not dense, no marginal bristles; pleuræ uniformly dusted with brown-gray pollen, meso and sternopleuræ pilose, hypopleural hairs black, the lowermost brown. Abdomen mostly polished, segments two to four with yellowish posterior fasciæ, the tomentum extending along middle of segments two, three, four and anterior two-thirds of segment five as a dorsal vitta, pile of abdomen entirely black, short, tufted on sides of second segment; base of hypopygium with stubby black setæ, lateral valves with two terminal prongs. Coxæ pollinose, the front pair with white hairs; femora shining black, flexor hairs yellowish, dorsal hairs mainly black and inconspicuous; tibiæ reddish brown, hairs black except towards apex of front pair where they are whitish, bristles strong, abundant and black; anterior tarsi yellow, hind tarsi reddish, the front pair with brush of yellowish-white hairs covering outside face, inside face with conspicuous black bristles, a few black bristles on flexor face of metatarsus, bristles of posterior tarsi heavy, numerous and black; basal half of claws yellow, apical half black, pulvilli white. Knob of halteres pale yellow. Wings sub-hyaline,a slight brownish tinge at furcations, anterior crossvein at basal third of the discal cell which is nearly four times as long as broad.

Female.—Prescutellar dusted area more extensive, dorsal stripe wanting on abdomen, pile of abdomen yellowish, longest on sides of basal segments. All tarsi reddish, almost no whitish hair on front tibiæ and tarsi, bristles of front tarsi stronger than in male.

Types. -Wolf Fork of Touchet River in the Blue Mountains of southeastern Washington. Three specimens, July 12-20, 1922. (V. Argo).

Cyrtopogon punctipennis, new species.

Male.—Length 7.5 mm. Closely resembling *C. nebulo* O. S. but without fimbriate costa. Vertex and face black with slight violaceous tinge, thinly overlaid with white pollen, more distinct along facial boundaries, pile of front fine dense and black, of face longer and more abundant, the individual hairs tipped with whitish, third antennal joint tapering, the arista nearly equal in length, slender with first segment distinct, occiput with light bluish tinge, orbits white pollinose, hairs very fine abundant and hairy. Thorax bluish-black in ground-color, median stripe of white pollen extending from neck to scutellum, dorso-central stripes of white pollen broadening behind, lateral and posterior margins largely blue pollinose, when viewed from in front the notum shows four silvery spots, the posterior ones on the suture, the anterior ones half way to the front margin; pile abundant and black, three fine lateral bristles; scutellum convex, shining blue-black, its silky pile long and white, no bristles, pleuræ uniformly and lightly cinereous dusted, ground-color blue-black, pile of pectus white, trichostichal hairs white and black mixed. Abdomen shining blue-black, extreme posterior corners of segments white pruinose, pile rather sparse short and pale, becoming darker in back, hypopygium very small, sunken, venter with bluish-gray pile, the hairs very dense on apical third. Legs entirely blue-black, front coxæ with abundant whitish pile, hairs of femora pale at base, front tibiæ with a row of very long bluish hairs on posterior edge, these hairs continuing on first three tarsal joints, hind tibiæ brown pubescent within, claws black, pulvilli brownish. Halteres black, calypteres alutaceous; wings lightly infumated, paler along portions of the first three veins, marked with distinct blackish spots at the bases of submarginal cells and of first and second posterior cells, the last two spots sometimes thickened and extending basally to the cross-veins, costa blackish from end of first vein to tip of wing.

Female.—Hairs somewhat shorter, notum more heavily pollinose so as to appear brownish in general color, median bisected stripe almost black; scutellum brownish pollinose, with about eight marginal setiform hairs; front legs marked with a prominent comb of hairs.

Types.—Moscow Mountain, Idaho, various dates from May to October (Melander); Pullman Washington; Goodnoe Hills, Washington (A. C. Burrill).

Cyrtopogon semitarius, new species.

Male.—Length 15 mm. Resembling *dasyllis.* Upper part of head black with abundant black hair, facial hair mainly white, along oral margin black, beard fine and white, palpal hairs black, antennæ black, style deformed, as wide as long, blunt, apically with a concavity in which the minute terminal joint is inserted. Thorax largely shining, a very narrow indistinct median line of grayish-brown dust, a mark of similar dust bearing the supra-alar bristles and a less extended similar mark above humeri, posterior half of mesonotum and scutellum shining black; hairs of thorax abundant, erect and black, of scutellum dense and black, no bristles; pleuræ with very faint touch of dust, mostly shining, black pile on meso, sterno, and hypopleuræ, the later dense and long. Basal three segments of abdomen uniformly and densly clothed with long pale yellow hair, apical half of abdomen shining and provided with dense short black pile, tip of hypopygium with a few yellow hairs; pile of venter entirely black. Coxæ and femora shining black, posterior tibiæ dark castaneous, tarsi reddish; pile of front face of front coxæ white, of exterior face of hind coxæ yellowish white; pile of femora mostly black, that of posterior face of front femora white, femoral bristles black; pile of extensor face of anterior tibiæ abundant and white, of entire hind tibiæ black, inner face of front tibiæ with fulvous pubescence, middle tibiæ with lateral black bristles, hind tibiæ with rows of black bristles, particularly on extensor, anterior and apical half of flexor faces; basal half of claws reddish, apical half black. Stem of halteres black, knob pale yellow. Wings hyaline, veins black, anterior crossvein at basal fifth of discal cell, the discal cell nearly five times as long as wide.

Holotype.—Alta Vista, Mt. Rainier, Wash., July 29, 1922 (Melander).

The specimen was taken from its vantage position on one of the ghost trees on the Alta Vista ridge. The structure of its style is unique but is probably not the result of a deformity, since the two antennæ are alike.

Cyrtopogon tacomae, new species.

Closely related to *C. rufotarsus* Back. Ground-color entirely black, thorax beautifully marked with silvery white pattern, extensor face of front tibiæ and tarsi of male densely covered with appressed silvery-white hairs, middle legs normal, anterior and extensor faces of hind tibiæ of male with white hairs, front and hind tarsi sometimes fuscous.

Male.—Length 10 mm. Antennæ black, third joint broadening underneath, thickest at two-thirds its length, style one-fourth as long as the third joint; front and face heavily silvery-gray, occiput subshining, more whitish at orbits, facial gibbosity nearly hemispherical, its central hairs long and silvery-white, mystax entirely black, beard largely white, frontal hairs long, delicate, not abundant, black. Thorax viewed from above presenting the following pattern in dark brown pollen: a bisected median stripe contiguous with a presutural round spot, and the entire postsutural area except postalar callosities and a narrow triangle in front of the convex shining scutellum, —this brown picture changing to shining black when viewed from behind; viewed from in front the anterior portion of the mesonotum is silvery-white pruinose, but from above a posthumeral area appears subshining black; all hairs of thorax black; pleuræ subshining lightly coated with brownish dust, but whitish pruinose above front coxæ, on upper sternopleura and narrowly along posterior part of mesopleura. Abdomen polished black with slight violaceous tinge, lightly dusted on apical segments, hypopygium polished, interrupted silvery-white fasciæ along posterior part of segments 2-6, narrowly leaving the hind margin on segments 2, 3 but attaining the hind edge on segments 4-6, the marks of the sixth segment less distinct, all hairs of abdomen black, those at sides of first three segments long and almost tufted. The silvery hairs of front tarsi cover the ground-color; the middle tarsi are always black, the front and hind ones sometimes are brown but usually are quite black; inner face of front tibiæ and metatarsi densely coated with glistening fulvous depressed short pubescence, similar fulvous pubescence extends along posterior face of hind tibiæ; pulvilli and basal third of claws brown. Halteres with yellowish knob; wings with brownish tinge and with brownish markings occupying the root, auxiliary cell, furcation of veins, crossveins, and forming an oblique band along first section of third vein, the anterior crossvein at basal fifth of discal cell.

Female.—Larger by one or two millimeters. Front largly ightly dusted with brown, face and central hairs less pure white.

Tarsi usually black, sometimes reddish, lacking the silvery ornamentation of the male. Notal picture more definite, humeri appearing subshining only when viewed from above, posthumeral spot of male appearing silvery-white, a quadrate prescutellar area emitting two anterior extensions pruinose, base of scutellum lightly pruinose; whitish pruinosity of pleuræ more extended, the entire mesopleura except central brown spot pruinose, pile of sides of prothorax and of sternopleura white. Hairs at base of abdomen pale yellow and less conspicuous, sides of first segment also with pruinosity, sixth and following segments entirely shining black. Wing markings less distinct, auxiliary cells hyaline.

Types.—Mount Rainier, Washington, various places in the natural parks visited at about 5000-6000 feet elevation. In all over ninety specimens were secured, including four collected by Dr. Aldrich. The flies were observed alighting on stones in the sunny pathways and were encountered in Paradise Park, Van Trump Park, and Indian Henry Hunting Ground, on Alta Vista, Mt. Ararat, and Crystal Mountain.

A grant from the Elizabeth Thomspon Science fund for the purpose of studying the alpine insects of Mount Rainier made possible the securing of much of the type material. Paratypes have been deposited in the National Museum, the Canadian National Museum, the Museum of Comparative Zoology of Harvard and the Philadelphia Academy of Science.

Cyrtopogon vulneratus, new species.

Male.—Length 10 mm. Readily distinct in having a large spot of heavy fulvous tomentum beginning at middle of second segment of abdomen and reaching to hind margin of fifth. Front and face thickly clothed with pale golden tomentum, a denuded spot between antennæ and front ocellus, facial hairs yellow, mystax black, frontal hairs sparse, fine and black: upper occiput rather lightly dusted with dull yellow pollen, brighter along orbits, a denuded spot underneath each ocellus, hairs sparse and black, lower occiput with brighter yellow dust, beard silky delicate and white; antennæ black, basal joints equal, hairs few and black, third joint slightly longer than basal joints together, style acuminate, one-eigth the length of the third joint. Pronotum shining black, a median inverted trianglar mark and a subhumeral spot of golden pollen, sides with tuft of white pile; mesonotum tomentose except postalar callosities and adjacent area, median geminate stripe light brown, interrupted a short distance behind suture, the usual broad lateral stripe consisting of a vaguely rounded mark on each side of suture, humeri golden, front part of mesonotum golden-gray, rear middle part cinereous; notal hairs short, sparse and black, lateral bristles black; scutellum convex, shining black, a touch of yellow pollen at base, no discal hairs, marginal hairs sparse and black; pleuræ lightly cinereous, more golden above, pteropleura shining, trichostichal hairs white. Abdomen slender, shining, sides of first segment with tufted white pile, of second segment with looser white hairs, third and fourth segment with short fulvous hairs; fifth, sixth and seventh segments and hypopygium with black hairs, posterior margins of second to fifth segments laterally golden tomentose, hypopygium globose, wider than termination of abdomen; venter black, hairs yellow. Femora black, tibiæ and tarsi reddish except apex, hairs largely whitish, bristles black, two strong yellow bristles near middle of anterior face of hind femora, inner face of front and hind tibiæ with close deep golden pubescence, claws black with brown base. Halteres and calypteres yellow, wings broad and hyaline, veins piceous, yellowish at base, a very faint cloud over crossveins, anterior crossvein at one-fifth length of discal cell, anal cell briefly open.

Holotype.—Coniston, Ontario, 27, July (H. S. Parish).

NOTES ON A NEW ENGLAND ARADID.

By Geo. W. Barber.

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Among the species of the very interesting family *Aradidæ* that occur in New England is *Aradus 4-lineatus* Say.* It is not uncommon, being found beneath the bark of dead trees, particularly old stumps and logs where the fungus on which it feeds grows abundantly. On this fungus the eggs are laid and the young feed.

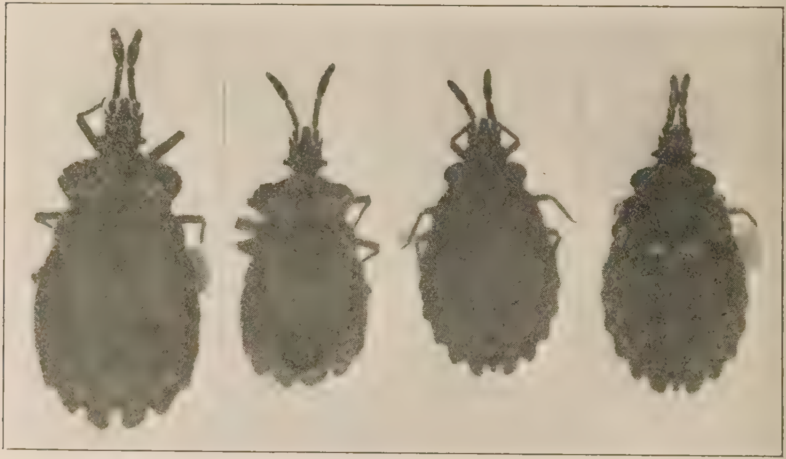

Fig. 1. *Aradus 4-lineatus* Say. From left to right, adult female, adult male, full-grown nymphs.

The eggs are closely cemented to the fungus and those which I have seen, always laid singly, oviposition continuing for some time. During 1920 one female in a cage deposited 13 eggs from May 16 to June 2 In 1922 eggs were obatined from June 14 to June 18. In all, ten eggs hatched in from 16 to 18 days the average incubation period being 17.8 days. Six first instar nymphs moulted in fron 8 to 13 days, the average length of the first instar being 11.1 days. Males that I confined in cages lived from 28 to 30 days, females from 14 to 35 days.

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*Determined by H. M. Parshley.

Lugger, in the 6th. Rep. Div. Ent. Minnesota. St. Exp. Sta. 1900 p. 40 described the egg of an *Aradid*, probably *Aradus robustus* Uhl. as follows; "the eggs glistening white in color are deposited under the bark."

Heidman, 1911—Proc. Ent. Soc. Wash. XIII p. 134 described the egg of an *Aradid, Neuroctenus simplex* as ;"Egg about 1mm. long 5mm. wide; laid in a heap numbering from 20 to 60 or more. Chorion whitish, irregular, coarse, hexagonal; no apical cap; the chorial processes seem to be wanting."

The egg of *Aradus* 4-*lineatus* Say is quite different in structure and the habit of oviposition is dissimilar. It differs in structure particularly in the flattened ventral surface and in possessing both a distinct cap and chorial processes, altho the latter are very minute and inconspicuous. The habit of oviposition differs in that all those which I have seen are deposited singly as previously mentioned.

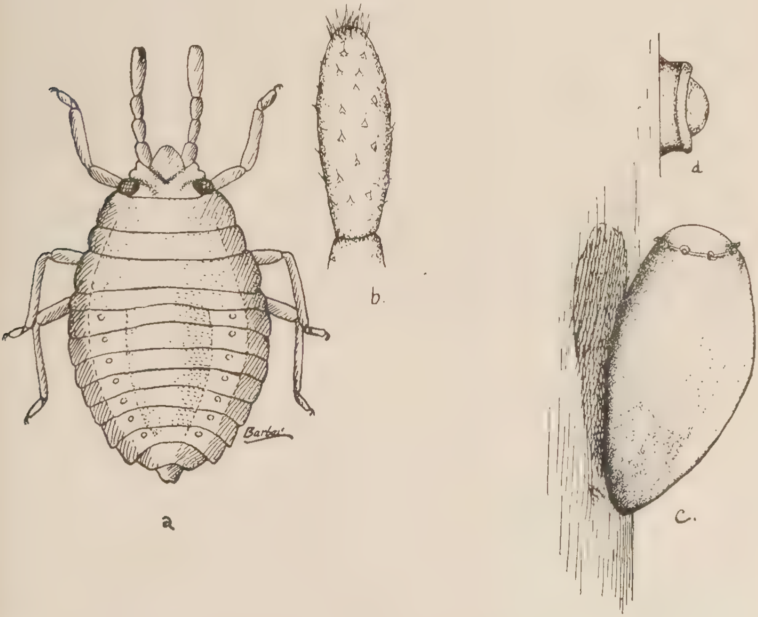

Fig. 2. *Aradus 4 lineatus* Say. a, first instar nymph; b, apical joint of antennæ of first instar nymph; c, egg, viewed laterally; d, corial process of egg.

THE EGG.

Length 1.2 mm.; width at middle .8 mm.; thickness at middle .425 mm.

Color, light red, smooth, moderately shining; viewed dorsally oval, narrowing towards the cap; flattened ventrally for a half to three fourths of its surface where it adheres to the fungus, the cap somewhat raised; cap not prominent, chorial processes ten in number, placed in a circle about the cap, minute, cup-shaped, raised but little above the chorion, a white hemispherical protuberance sometimes protrudes from the apex.

THE FIRST INSTAR NYMPH.

Length 1.2 mm.; width .7 mm. Color light red, the legs lighter, nearly cream color, femura lighter red, apical joint of antennæ and eyes dark; general aspect of body flattened; head with a groove rising before each eye, curving towards the Posterior line of the head, which it nearly attains, and somewhat towards the median line; eyes moderately prominent; beak scarcely reaching the anterior edge of the third ventral segment; antennæ one third the length of the body, 4-jointed, apical joint widest, as long as the third and fourth together, minutely and sparsely tuberculate, apically bearing a few very minute hairs; thorax slightly wider than eyes; abdomen evenly rounded at the sides, a third longer than the thorax and somewhat broader; edge of the thorax and abdomen foliaceous.

ON THE WING-VENATION OF INSECTS

By Aug. Lameere.

Translated by Austin M. Brues

The admirable method discovered by Comstock and Needham,[1] of showing homologies in the wing neuration of various types of insects does not allow us, unfortunately, to discover veins which have disappeared during the course of evolution. It is absolutely necessary to make a study of fossil forms in order to complete the ontogenetic data by means of information derived from the connections and topography of the veins in ancestral types which no longer exist.

No living insect possesses neuration as complete as that of many fossils from the coal measures; the result is that Comstock's[2] scheme of the fundamental primitive neuration is inexact, for it is based on living Perlids. To take this scheme as a basis of comparison leads to confusing entirely different veins under the same heading. That is what has happened notably with the Ephemerids and Odonata, of which the neuration does not seem to me to have been well understood.

We know that ontogentic study shows two tracheæ penetrating the wing; the ramifications of the anterior trachea correspond to the costal, sub-costal, radial, and median nervures; those of the posterior trachea correspond to the cubital and the three anal nervures.

The radial nervure presents two branches: the radial, strictly speaking, and its sector.

In the wings of the Ephemerids, the Odonata, and the Protohemiptera from the coal measures, the median nervure forks, not far from the base of the wing, into two branches which I have termed the anterior median and the posterior median[3]; that is to say the median has exactly the same configuration as the radial, so that the posterior median can be considered as the sector of the anertior median. The comparison of the form of the median with that of the radial follows, if it is assumed that the radial is a high nervure while its sector is a low nervure; then the anterior median is a high nervure, the posterior a low nervure.

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[1] Sur la nervation alaire des Insectes. Bull. Class. des Sci. Acad. Roy. Belgique, 1922 pp. 38-149.

The sector of the median is missing in the Perlids and consequently does not figure in Comstock's scheme. I have shown that this nervure is very short and that it rejoins the cubital, or rather that it is completely lost in all the Orthoptera (*sensu latissimo*, including the Perlids); Tillyard has also shown that the same thing happens to the sector of the median (which he calls M^5) in the Holometabola.[4]

The cubital nervure has a configuration exactly like that of the radial and median; even nearer the base of the wing than does the median, it divides into two branches, an upper anterior, which I have called anterior cubital, and a lower posterior, the the posterior cubital, which is in a way the sector of the cubital.

Thus radial, median, and cubital show an identical form among the primitive insects, consisting of an upper vein followed by a lower sector.

Now we may ask if the same plan does not apply to the other nervures.

The costal is a high nervure, the sub-costal a low nervure, although the sub-costal appears not to be a branch of the costal, but arises directly behind the costal from the anterior tracheal (trunk) of the wing, it seems to me that we must admit that the sub-costal is the sector of the costal.

In the living insects only three anal nervures are found; but an examination of the fossils from the coal measures shows that there are apparently many more, for they are branched. I distinguish a first upper anal, a second lower anal, a third upper anal followed frequently by lower branches. I believe that we find but two anal nervures, the so-called second anal being the sector of the first.

The wing thus contains six (principal) nervures, three forming the anterior group: the costal, the radial, the median; and three belonging to the posterior group: the cubital, a first anal (1A) which we may call the *penultimate*, and a second anal

(3A) which we may call the *ultimate*; each of these six nervures is high and has a low sector.

Consequently we return, in the oldest insects known, to that regular alternation of high nervures and low nervures included in Adolph's old hypothesis. We can even use the nomenclature of J. Redtenbacher, accepted by C. Brongniart, numbering the nervures from I to XII, the odd numbers designating the primary nervures and the even numbers their sectors.

To adapt these ideas to the nomenclature of Comstock and Needhan, which is today universally accepted, I propose to designate all the sectors by the names of their respective nervures, adding to these names the prefix *sub*.

Then we shall have in the first group: the costal, high (C or I), with the sub-costal, low (Sc or II): the radial, high (R or III) with the sub-radial, low (Sr or IV): the median, high (M or V), with the sub-median, low (Sm or VI) and, in the second group: the cubital, high (Cu or VII), with the sub-cubital, low (Scu or VIII): the penultimate, high (P or IX), with the sub-penultimate, low (Sp or X): the ultimate, high (U or XI), with the sub-ultimate, low (Su or XII).

The sub-radial, the median, the sub-median, the cubital and the sub-cubital are each forked twice in the primitive insects, giving two limbs and four branches; we have then, adapting the the data to the accepted nomenclature: Sr^1, Sr^2, Sr^3, Sr^4,: M^1, M^2, M^3, M^4, Sm^1, Sm^2, Sm^3, Sm^4; Cu^1, Cu^2, Cu^3, Cu^4; Scu^1, Scu^2, Scu^3, Scu^4.

The general evolution of insect wings is characterized by a lengthening which is concurrent with a diminution of the breadth; this phenomenon has been accompanied by the disappearance of certain longitudinal nervures; but these are not the same nervures which have disappeared if we consider the two great groups of Pterygota; a misunderstanding of this fact has caused a regrettable confusion.

With all the insects whose embryogeny has caused them to be called Ectoblastic[5]—that is to say the Paurometabola (*sensu latissimo*, the Orthoptera) and the Holometabola,—we have made mention of them above,—the sub-median as is reduced to a ver short nervure rejoining the cubital, or perhaps as is more fre quently the case, it aborts completely. What is called the median in the Pterygota (M^1, M^2, M^3 M^4) is then really our own median that is to say the upper anterior branch of the third nervure of the first group, and there is no change in the terminology

As for the Endoblastic Pterygota (Subulicornia and Rhyn chota) more primitive than the Ecoblastic forms, it is entirely otherwise. Here the neuration is complete, or rather if the longitudinal nervures disappear it is never the sub-median alone but very often the anterior median and also the anterior cubital the narrowing of the wing ordinarily involving the spaces adjacent to the sub-median. This I shall have to show by palaeontology, for the ontogeny of living forms not only has been insufficient to show this peculiarity, but has at the same time le zoologists to form totally erroneous homologies.

It is in the Ephemeroptera of the group Spilapteridæ fro the coal measures that we meet with the most complete neuratio this suits our scheme completely (e. g. Lamproptilia Ch. Brongn. in certain genera, however, the anterior median and anteri cubital may be simple; that is, not branched.

Everyone agrees in considering the Stephanian genu *Triplosoba* Handl. (Blanchardia Ch. Brongn.), type of th Protephemeroidea, as the precursor of the real Ephemeroidea which are found already in the Permian; the neuration is th same as that of the Spilapteridæ, in which the anterior media and cubital are represented by a simple nervure (*e. g.*, Apopappu Handl.); but there are adventitious sectors in the sub-radial sub-median, and sub-cubital spaces; the sub-median is simply forked, and between its branches is an adventitious sector.

Now if we compare the wing of the Ephemeroids of th Permian, Secondary, Tertiary and the present day to that o Triplosoba, the configuration and connections show at one that the lower nervures considered by Comstock as M^1 and M with the adventitious sectors between, correspond to Sr^1 an Sr^4 of Triplosoba, that is to say, the sector of the radial has bee wrongly considered a branch of the median, because of the fac hat the latter is reunited at the base, which, from a morpho-ogical standpoint, is of only relative importance; it is seen that Comstock's M^3 and M^4, with the adventitious sector between, are Sm^1 and Sm^4; that Cu^1 and Cu^2, low nervures, with the adventitious sector between, are Scu^1 and Scu^4; that 1A, high, s P; 2A, low, is Sp; 3A, high, is U.

The high nervures M and Cu, which are present and simple n Triplosoba, are missing between Sr^4 and Sm^1, in some cases, between Sm^4 and Scu^1 in others; we may consider that they have disappeared, in consequence of the narrowing of the wing, a change which becomes very marked with the Protereismidæ of the Permian.[8]

It is very interesting to show the Sm and its branches are high in the *Ephemeroidea*, while these nervures are low in *Triplosoba*, which brings back the regular alternation of high and low nervures broken up by the disappearance of the adjacent high nervures *M* and *Cu*.

The wings of the Ephemeroidea differ from those of the Protephemeroidea by the reunion of the median with the sector of the radial near the base of the wing, by the disappearance of the anterior high median and cubital, the sub-median and sub-cubital alone remaining, the sub-median having become a high nervure.

Following the conclusion of a work by Miss Morgan[9] Comstock agreed that in the Ephemeroidea the radial sector is represented by a small trachea arising from the radial, not far from the extremity of the wing; he considered as belonging to the sector of the radial the two final added sectors situated in the space which I have called sub-radial, and in which it makes a median space. These authors tried to discover in the wing of the Ephemeroidea the sector of the radial which they did not see, taking it for a branch of the median, and they sought the solution in a comparison with the wing of the Odonata.

None of Miss Morgan's drawings seem to me convincing; the numerous preparations of young larvæ of Ephemeroidea of different genera *Baëtis*, *Clœon*, *Leptophlebia*, *Cœnis*) made at the Overmeire biological station by Mr. Paul Brien, student-assistant, have shown us nothing which recalls anything of the singular arrangement existing among the Odonata of the group Anisoptera. We have not seen the small sector trachea described by Miss Morgan; supposing that it really does exist, it has only the value of an adventitious trachea, the only value which can also be attributed to the famous trachea which, according to Comstock and Needham, represented the sector of the radial in the Odonata.

Tillyard, to whom we are indebted for so many fine works on living and fossil insects, recently confirmed the opinion that the subnodal sector of de Selys-Longchamps among the Libellulidæ is the sector of the radial crossing the median nervure.[10] I was for a long time persuaded that this nervure, absent in the Zygoptera, as Tillyard has shown [11] is an additional simple nervure serving in the Anisoptera to close up the sub-radial space which was enlarged during the course of evolution; this nervure, which may be called the secant (S), is a physiological realization of what exists in the Neuroptera, where the enlarged sub-radial space is closed by a supplementary branch of the radial sector.

Tillyard's conclusion is that the neuration of the Odonata can be interpreted only by palæontology.

Here is the reply which I believe I can support, using as a basis what we have learned from the evolution of neuration in the Ephemeroidea, and what the evolution of the Odonatoptera shows us.

In the Odonata, the nervures which all present-day entomologists consider as M^1, M^2, Ms and M^3 are with me the four branches of the sector of the radial, Sr^1, Sr^2, Sr^3 Sr^4, the sector of the radial being, as in the Ephemeroidea, reunited at the base of the median; the upper anterior median (*M*) is represented alone by the high nervure at present designated by the symbol M^4; the posterior median (*Sm*) is absent; the anterior cubital (*Cu*) has disappeared, as in the Ephemeroidea; the nervure considered as Cu^1, low nervure, is the sector of the cubical (*Scu*); the nervure considered as Cu^2, upper nervure, is the first anal or penultimate (P), reunited at the base of the sub-cubital, the nervure 1*A* of current usage, high, is the third anal or ultimate (*U*), partly attached to the penultimate.

The neuration of the wing of the Libellulidæ would not be exactly similar to that of the Ephemeroidea, contrary to what has been considered heretofore, and the comparison which has been made with that of Ectoblastic insects is rather lame.

The evolution of fossil Odonatoptera, which I have been able to study at the Paris Museum, will show us this.

In the Dictyoneuridæ of the coal measures the primitive neuration is complete and typical, but very often the anterior median and anterior cubital are simple (as in the genus *Stenodictya* Ch. Brongn.)

Dictyoptilus Ch. Brongn., of the Stephanien, has a more elongated wing; the median is contiguous to the radial at the base of the wing, which gives a small pre-costal space,—all characters which are accentuated in the Protodonata[1].

These last have the median confused with the radial at the base of the wing, and the radial sector arises from the median, as in the Ephemeroidea.

Let us now consider *Meganeura Monyi* of Ch. Brongniart, the giant Libellulid of Commentry, and compare its neuration, on one hand with that of Dictoptilus, on the other hand with that of the Odonata, the nervures being for the latter designated according to their current names.[2]

In Meganeura, we see, leaving the common trunk which leads to the radial, a nervure which soon divides into a lower anterior and an upper posterior nervure; the first (Brongniart'sV) corresponds evidently to the radial sector in *Dictyoptilus*, and it divides, as in the latter; into two low nervures Brongniart's IV and V) in which we recognize, on one hand, $M^{1\ 2}$ Ms; on the other, M^3, of the Odonata; the second (Brongniart's VII) is the median in *Dictyoptilus*, which is reunited to the radial at the base of the latter's sector; this median is divided into a high nervure, the anterior median, in which we recognize M^4 of the

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[1] See the fine photographic reproductions of the wing of *Dictyoptilus* (*Cockerelliella*) *sepultus* F. Meun, published by Boule in the Annales de Paleontologie, vo. 7, pl. 7, figs. 4, 4a.

[2] The figure of the wings of *Meganeura monyi* in the work of Brongniart (Pl. 42) is correct; in Handlirsch the fore wing is in part inaccurate.

Odanta, and a low nervure, the posterior median; this last the Odonata, and a low nervure, the posterior median; this last is missing in the Odonata, which have retained only the upper anterior median.

From the base of the wing of *Meganeura*, a little behind the radio-median trunk arises a long, winding, simple nerve (Brongniart's VIII) which is very low; comparison with Dictyoptilus shows that it must be the posterior cubital (Scu), as the anterior upper cubital which approaches very near to the posterior median in *Dictyoptilus* is evidently absent. It is certain that this nervure Scu is represented in the Odonata by the low nervure at present known as Cu^1.

Still a third nervure leaves the base of the wing of Meganeura; it is parallel to the posterior cubital and is high (Brongniart's IX); almost on the level at which the radial detaches itself from its sector and from the median, this high nervure gives rise to a low nervure (Brongniart's X); we now have the first and second anal, the penultimate nervure with its sector, and this nervure corresponds to Cu^2 of the Odonata.

We know that in the Odonata a trachea gives rise to Cu^1 and Cu^2, these nervures proceeding from a common trunk, and another trachea furnishes the nervure designated as 1A; this last attaches itself very near the base of the wing to the common trunk of Cu^1 and Cu^2, and then becomes independent.

We have the same thing with Meganeura and even probably with Dictyoptilus; no attention has been paid to it, because Ch. Brongniart has neither seen nor figured anything, except in Meganeura; between the base of the wing and the level of the division of the penultimate into P and Sp, there exists an oblique nervure which attaches the cubital again to the last nervure arising from the base of the wing. [1]It is evidently a case of an anastomosis between the cubital and the penultimate, the latter proceeding thus from the cubital, as in the Odonata. So the last nervure which leaves the base of the wing in *Meganeura* is only the ultimate; it corresponds to 1A in the Odonata, and, just as with the latter, it is attached along a certain length to the nervure which precedes it, supporting the secondary nervures which are opposite in direction to those which are supported by the sector of the penultimate. The Protodonata also seem to have three anal nervures, *P*, and *Sp* and *U*, *U* rejoining the common trunk of *P* and *Sp* after this has left *Scu*.

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[1] This oblique nervure is immediately recognizable in the photographic reproduction of a wing-fragment of Meganeura, given by Bolton (Quart. Journ. Geol. Soc., vol. 70 (1914), pl. 18, fig. 1) and in that of another Meganeura published by Boule (Ann. de Paleont, vol. 4 (1909) pl. 17, fig. 2); E. H. Sellards has figured it in *Typus permianus* (American Journ. Sci., vol. 23 (1907), p. 250, fig. 1, p. 252, fig. 2.

In the Odonata, on account of the attenuation of the base of the wing, the attachment of the sub-cubital and penultimate extends farther than in the Protodonata, the sub-penultimate is missing, and the ultimate is attached in part to the portion common to *Scu* and *P*.

The essential differentiation between the Protodonata and Dictyoptilus lies in the reunion of the median to the base of the radial and the disappearance of the anterior cubital; the Odonata are derived from the Protodonata by the suppression of the posterior median and of the sector of the penultimate nervure.

It remains for us only to inspect the neuration of the Rhynchota. Is what we call the median in Endoblastic insects the nervure *Sm* of the Subulicornia or rather the nervure M of the Ectoblastic insects? The study of existing forms does not permit us to decide. Let us then have recourse to palæontology.

The numerous Protohemiptera of the coal measures[12] offer a complete wing-neuration; but in all the anterior median is simple, and the anterior cubital is ordinarily so.

The real Hemiptera, Rhynchota which undoubtedly descend from the Protohemiptera and of which a representative is known in the Stephanian, have a forked median and cubital, and the two branches of these are ramified. It is sufficient to consider the neuration of the permian genera Scytinoptera and Prosbole, in Handlirsch's Atlas to be presuaded that with neither the Homoptera nor the Heteroptera is there an anterior median or an anterior cubital, that the position of these nervures is occupied by a great empty space and that the two forked nervures are the sector of the median and the sector of the cubital.

The evolution of neuration in the Hemiptera thus takes place in the same way as with the Ephemeroptera, a new proof that the Endoblastic insects may be placed opposite to the Ectoblastic in classification.

Conclusion.

The scheme of primordial wing neuration worked out by Comstock is useful only for Ectoblastic insects, which have lost the posterior branch of the median nervure, and that since their appearance in the coal measures.

The Endoblastic forms, Subulicornia and Rhynchota have, for the most part, in the coal measures, a complete neuration conforming to a scheme in which six low nervures alternate with six high nervures; those between in which the wings do not agree with this type, notably all the forms which have persisted beyond the Permian, have lost other longitudinal nervures than the Ectoblasts.

The Ephemeroptera, the Protodonata, the Odonata, and the Hemiptera do not possess the anterior branch of the cubital nervure; the Ephemeroptera and Hemiptera lack also the anterior branch of the median nervure; the Protodonata, as well as the Odonata, have retained this, but the Odonata have lost the posterior branch of the median nervure.

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BOOK REVIEW

"Les Termites. Partie Générale." by E. Hegh. Bruxelles, September 1922. published by Imprimerie Industrielle & Financière (Société Anonyme), 4 rue de Berlaimont, Bruxelles. Price $6.00. 756 pp., 460 figs. Review by Alfred Emerson, Department of Zoology, University of Pittsburgh.

Mr. Hegh has done a remarkable piece of work in the gathering of information and the arranging of facts which have been brought together in this large book (756 pages) profusely illustrated with the best drawings and photographs which have been published on termites.

It is a compilation, but a compilation of such thoroughness that one has no hesitation in pronouncing it as valuable to students of termites and to entomologists in general as new extended observations on the insects would be. Although termites (Isoptera) constitute one of the smaller orders, there being a little over 1000 species described and a bibliography of a little more than 1200 titles, the gathering of all the important biological material is an enormous task.

Everything known at the present time concerning the biology of this fascinating group of social insects is dealt with; their geographical distribution; their caste system and the function of the various castes in all the groups of termites; their nourishment and modes of obtaining it; their nests, the classification and construction of the nest; their predaceous enemies, parasites, termitophiles, and associates; their influence on vegetation and physiography; the utilization of termites as food by man; these and many other subjects are dealt with in a most thorough manner. An extended bibliography is added with a list of the African species.

The economic problems are not emphasized although many photographs of their damage are given and their feeding habits are discussed at great length. Methods of control are not discussed. It is a monograph on the biology of this group. Of course the errors made by the various students of termites have been prepetuated in various parts, each statement, however, being ascribed to the authority. As a whole the information given represents the viewpoint of the modern investigators and observers of termites.

This book should be in every entomological library and undoubtedly will be the best reference and source book on this order of insects yet written and likely to be written for many years.

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